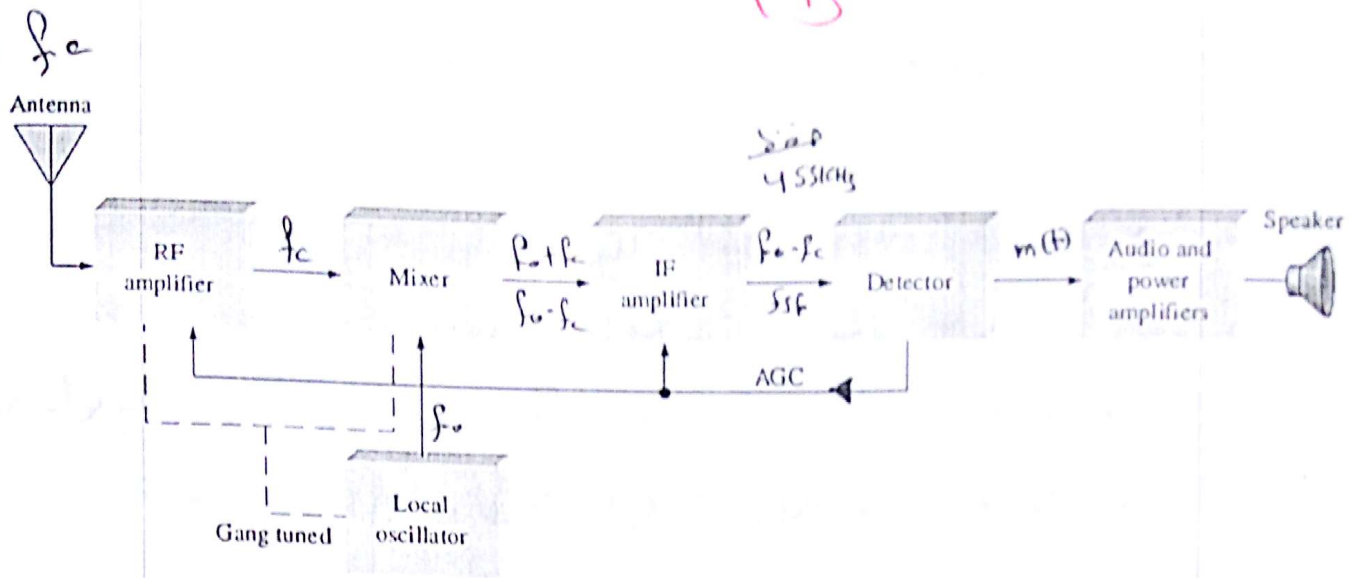


③ Superhetrodyne Receiver

(141)



Main idea of operation

- * the Superhetrodyne RX takes the incoming radio frequency signal ~~and~~ (f_c) and transform it to fixed frequency called intermediate frequency f_{if}

$$\begin{aligned} f_{if} &= 455 \text{ KHz} \rightarrow \text{AM} \\ f_{if} &= 10.7 \text{ MHz} \rightarrow \text{FM} \end{aligned} \quad \left. \vphantom{\begin{aligned} f_{if} &= 455 \text{ KHz} \rightarrow \text{AM} \\ f_{if} &= 10.7 \text{ MHz} \rightarrow \text{FM} \end{aligned}} \right\} \text{fixed}$$

- * So we get fixed performance for all received signals

و لیسیم یکتا ترددات را با فرکانس f_c الی تردد و
فقط f_{if} و به این ترتیب می توانیم به راحتی با یکدیگر

$$f_c \rightarrow \boxed{\text{Mixer}} \rightarrow f_o - f_c = f_{if}$$

f_o (8)

وتكونه الـ Super heterodyne Receiver

Antenna $\Rightarrow$ الكهرومغناطيسية الى استارة كهرسنة

① Rf Amplifier :

معالجة مع high freq Amplifier يقوم بتأجيل الاستارة الى استقبال f_c
من قطع اذقته الـ sensitivity

كما انه يقوم مع Variable Rf tuned Circuit حيث يتم بواسطته
اختيار الخط المطلوب وعمل reject للمكونات الغير مرغوبة وبذلك
تتم قسمة الـ selectivity

② Mixer $\Rightarrow$ يقوم بعمل mix لكلا f_c و f_o و $f_o < f_c$
النتيجة مع الفرض $f_o - f_c$ و $f_o + f_c$

الهدف الرئيس من الـ Mixer هو الفرض $f_{IF} = f_o - f_c$ والذي
هو تردد ثابت وبالتالي يتم قسمة وتثبيت الـ Rx Performance

③ Local oscillator

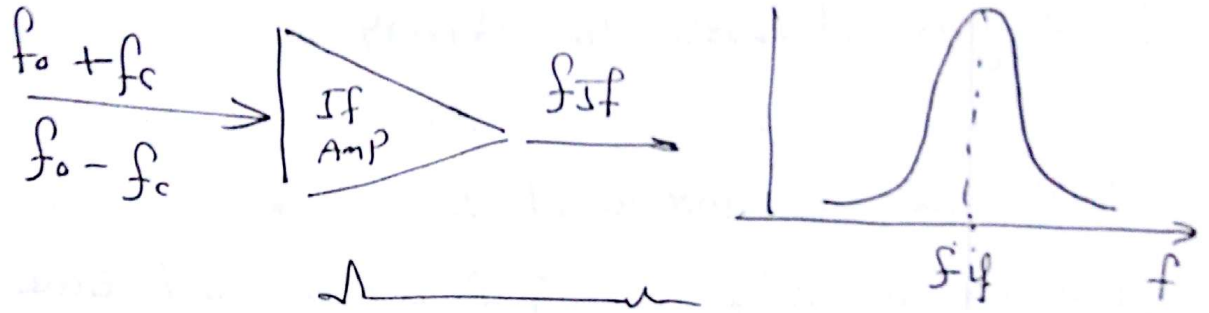
هو عبارة عن Variable oscillator يقوم
بإنتاج تردد f_o والذي يتم عمل الـ Mix مع f_c

تتم التحكم في كلا f_o و f_c الذي تم اختياره مع
طريقة الـ Rf tuned circuit
عند نفس الوقت بحيث يكون ثابتاً
 $f_o - f_c = f_{IF} = 455 \text{ KHz}$

④

If Amplifier

- هو عبارة عن Amplifier تكبر الإشارة وكذلك يكون على If filter لكي يمر الفهر فقط ويمنع البقية Selectivity



⑤ Detector

هو عبارة عن envelope detector، يمتص الإشارة $m(t)$ ويخرج

⑥ Audio Amplifier

هو ممتص هو يرفع مستوى الصوت البار في الإشارة $m(t)$ من تشغيل السماع

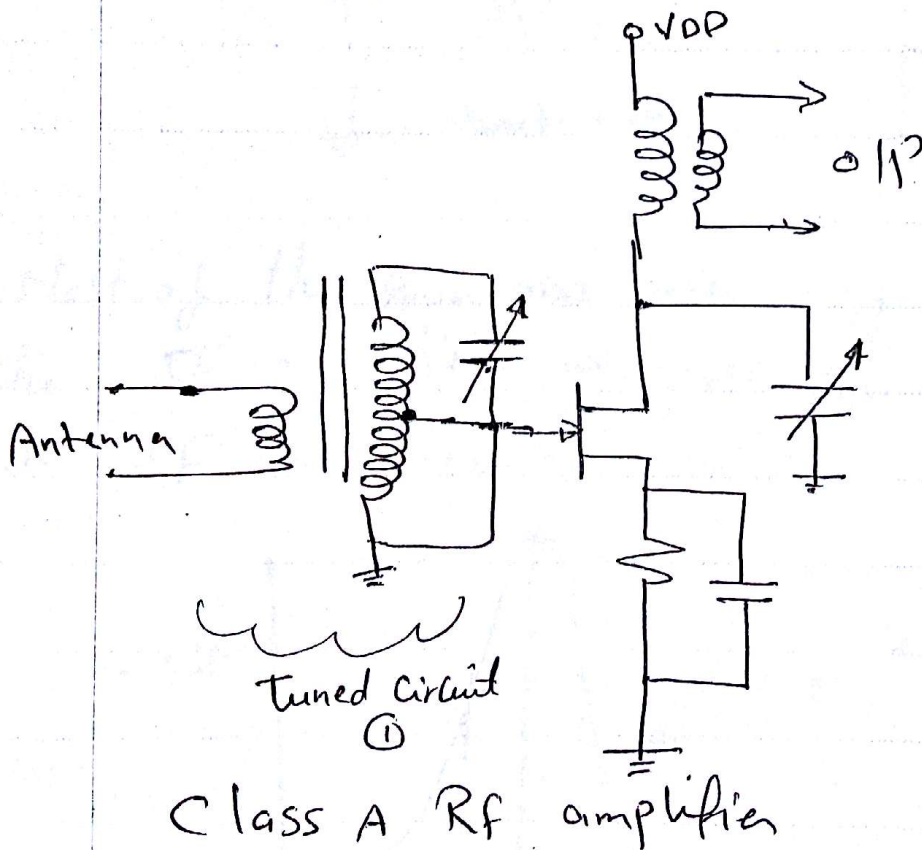
⑦ Automatic Gain Control AGC

يقوم بالتحكم في Gain كلاً من If and Rf Amplifiers بحيث تضمن أن مستوى الإشارة الذي يصل إلى Detector ثابت وبالتالي يكون مستوى الإشارة للمحطات البعيدة هو نفسه للمحطات القريبة

Superhetrodyne AM Rx

lect 2

- ① RF amplifier $\Rightarrow$ Provide high gain to improve Sensitivity.
 $\Rightarrow$ Provide high selectivity using tuned Circuit
 $\Rightarrow$ Called Low noise amplifier (LNA)
 $\Rightarrow$ Consist of class A power amplifier $\Rightarrow$ for linearity.
 $\Rightarrow$ Circuits contain BJT or FET Transistor

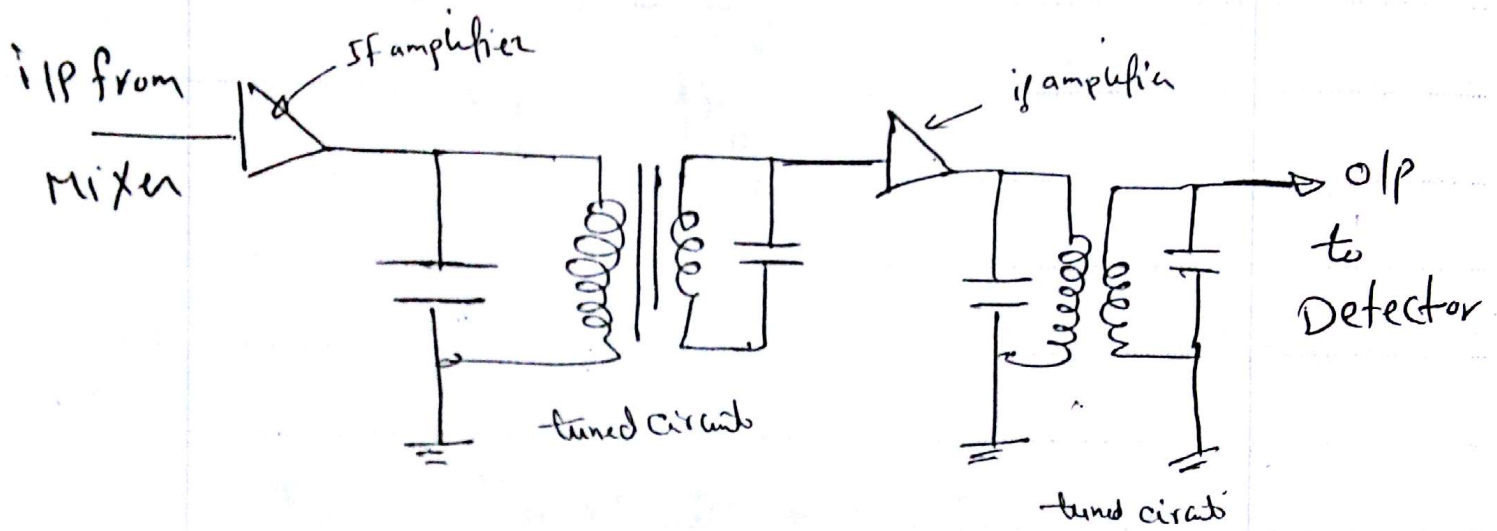


تuned circuit

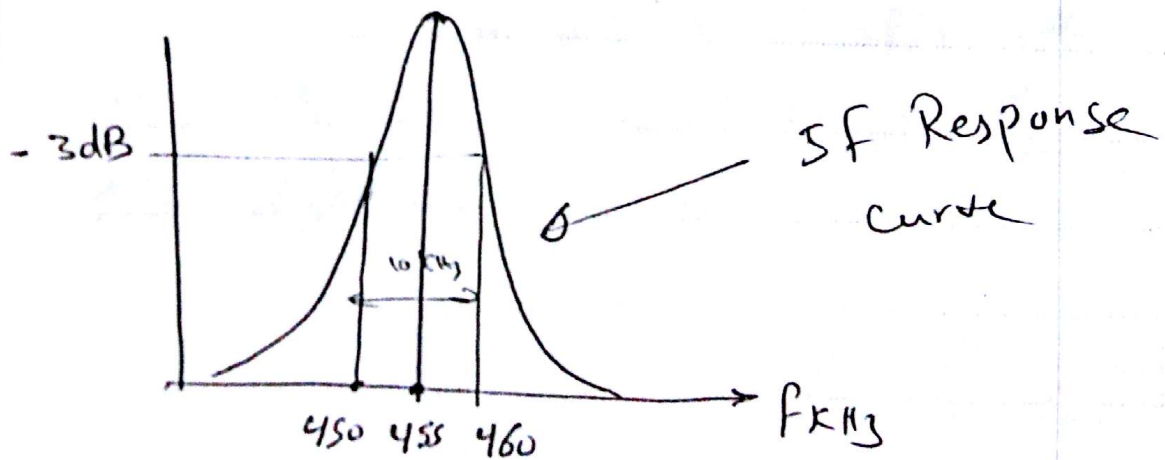
①

IF Amplifier :

- * Respond only to 455kHz and any side frequencies lying in the 10kHz Bandwidth
- $\Rightarrow$ has a tuned circuit at its i/p or o/p centered at 455kHz with 10kHz BW



- * Most of the gain and selectivity are produced by the IF amplifier $\rightarrow$ So we use two or more IF amplifiers

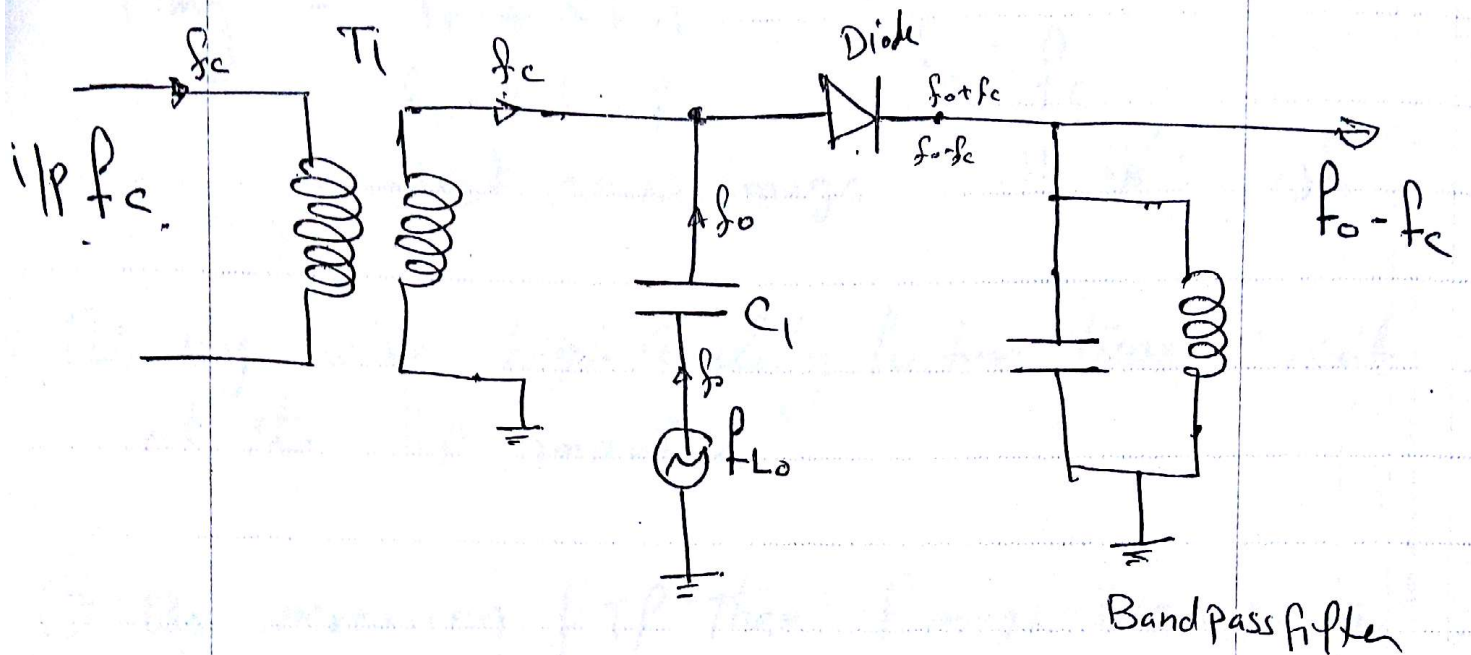


BW = 10kHz for AM

Mixer,

Nonlinearity
Diode Mixer

التيار غير خطي في دايود
التيار غير الخطي هو



التيار يدخل الدايود في تردد f_c والحث في T_1

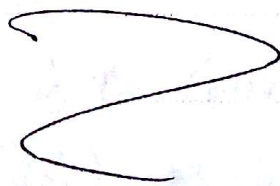
التيار يخرج من الدايود في تردد f_o والحث في C_1

التيار يخرج من الدايود في تردد $f_o + f_c$ والحث في f_L0

التيار يخرج من الدايود في تردد $f_o - f_c$ والحث في f_L0

$$(f_o - f_c) < (f_o + f_c)$$

then the tuned circuit select only
the difference $f_o - f_c$



Solving image Problem

$$f_{\text{img}} = f_c + 2f_{\text{IF}} \quad \leftarrow f_o > f_c$$

$f_o + f_{\text{IF}}$ image f_c

~~~~~ طيف ~~~~~

① By using high quality factor tuned circuit at the RF amplifier

② By increasing  $f_{\text{IF}}$  then  $f_{\text{image}}$  increase & tuned circuit

~~~~~ طيف ~~~~~

+ وضاع كل شيء وهو أفضل من الكل البقية عن طريق

Dual-Conversion Receiver

Local oscillator (LO) و Mixer (M)

⇒ The first Mixer Convert the incoming signal (f_c) to a high intermediate frequency f_{IF1} to eliminate image

⇒ The second Mixer is to Convert the first (f_{IF1}) to lower frequency (f_{IF2}) as shown in the figure

Demodulator

Sheet 3

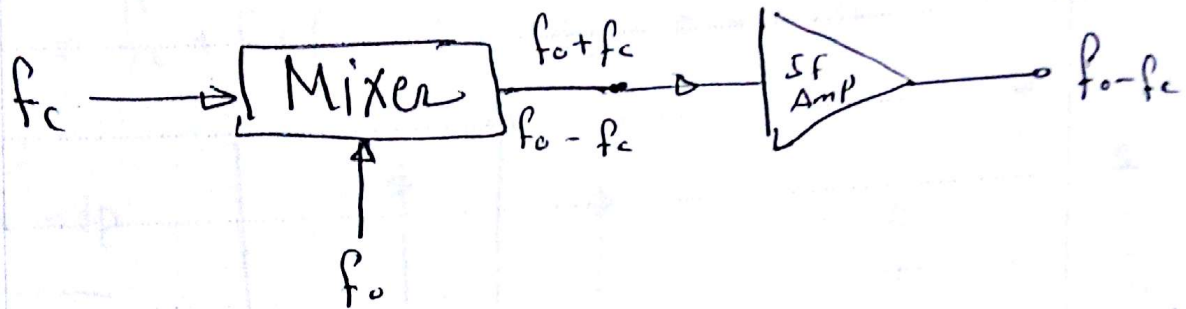
BASIC Am Receiver

1. The input to a certain AM receiver consists of a 1500 kHz carrier and two side frequencies separated from the carrier by 20 kHz. Determine the frequency spectrum at the output of the mixer amplifier and determine the frequency spectrum at the output of the IF amplifier.
2. For a carrier frequency of 1.2 MHz and a modulating frequency of 8.5 kHz, list all of the frequencies on the output of the mixer in an AM receiver.
3. Consider a superhet that receives signals in the 50-54MHz range with $f_{lo}=f_c+f_{if}$. Assuming there is little filtering prior to the mixer, what range of input signals will be received if the f_{if} is (a) 455 kHz. (b) 7MHz.
4. A superheterodyne receiver is designed to receive signals with carrier frequencies between 4 and 6 MHz with transmitted bandwidths of 100 kHz each. Its IF frequency is 850 kHz. What range of local oscillator frequencies is required using high-side injection ($f_{LO} > f_c$) ?
5. A radio receiver used in the AM system is shown below. The mixer translates the carrier frequency f_c to a fixed IF of 455 kHz by using a local oscillator of frequency f_{LO} . The broadcast-band frequencies range from 540kHz to 1600kHz. Determine the range of tuning that must be provided in the local oscillator (i) when f_{LO} is higher than f_c (superheterodyne receiver) and (ii) when f_{LO} is lower than f_c .

Sheet 3 - AM Rx

Q) $f_c = 1500 \text{ KHz}$ $f_m = 20 \text{ KHz}$

SOL

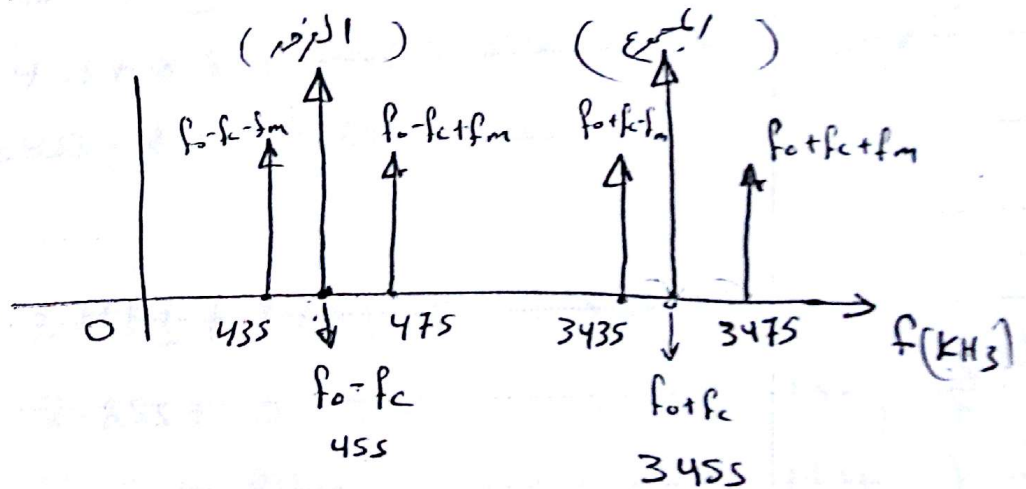


Let $f_{IF} = 455 \text{ KHz}$

$f_o = f_c + f_{IF} = 1500 + 455 = 1955 \text{ KHz}$

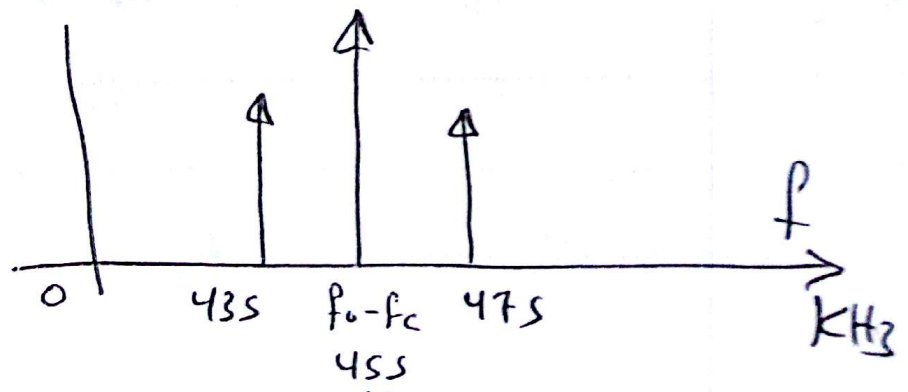
At Mixer o/p

التردد الخارج



At IF Amp o/p

التردد
عند



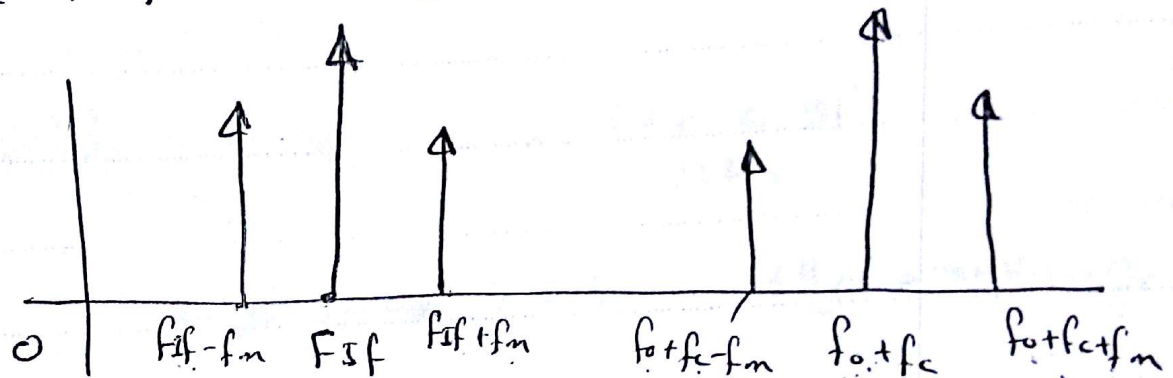
$$f_c = 1.2 \text{ MHz} \quad f_m = 8.5 \text{ kHz}$$

SOL

$$\text{Let } f_{IF} = 455 \text{ kHz}$$

$$f_o = f_c + f_{IF} = 1.2 \text{ MHz} + 0.455 \text{ MHz} = 1.655 \text{ MHz}$$

Mixer o/p



$$1) f_{IF} = 455 \text{ kHz} = f_o - f_c$$

$$2) f_{IF} + f_m = 455 + 8.5 = 463.5 \text{ kHz}$$

$$3) f_{IF} - f_m = 455 - 8.5 = 446.5 \text{ kHz}$$

الفرق

$$4) f_o + f_c = 1.2 \text{ MHz} + 1.655 = 2.855 \text{ MHz}$$

$$5) f_o + f_c + f_m = 2.855 + 8.5 \text{ kHz} = 2.8635 \text{ MHz}$$

$$6) f_o + f_c - f_m = 2.855 - 8.5 \text{ kHz} = 2.8465 \text{ MHz}$$

$$f_c = (50 - 54 \text{ MHz}) \leftarrow \text{little filter} \Rightarrow \text{image}$$

Sol

a) $f_{if} = 455 \text{ kHz}$

circ
bad tuned
circuit

$$f_{\text{imag}} = f_c + 2f_{if} = (50 \rightarrow 54) + 2 \times 455 \text{ kHz}$$

$$= (50 + 0.91) \text{ MHz} \rightarrow (54 + 0.91) \text{ MHz}$$

$$= 50.91 \rightarrow 54.91 \text{ MHz} \rightarrow \text{image range}$$

$\therefore$ New Range of Received signal $(50 \rightarrow 54.91) \text{ MHz}$



b) for $f_{if} = 7 \text{ MHz}$

$$f_{\text{imag}} = f_c + 2f_{if} = (50 \rightarrow 54) + 2 \times 7$$

$$= 50 + 14 \rightarrow 54 + 14$$

$$= 64 \rightarrow 68 \text{ MHz} \rightarrow \text{image range}$$

$\therefore$ The Range of ip signal $(50 \rightarrow 68) \text{ MHz}$

$$f_c = (4 \rightarrow 6) \text{ MHz} < f_m = 100 \text{ kHz} \quad \text{r} \quad f_{IF} = 850 \text{ kHz}$$

SOL

for high side injection ($f_{LO} > f_c$)

$$f_o = f_c + f_{IF}$$

$$= (4 \rightarrow 6) + 850 \text{ kHz}$$

$$f_o = 4.85 \rightarrow 6.85 \text{ MHz}$$



$$\textcircled{5} \quad f_{IF} = 455 \text{ kHz} \quad f_{LO} = ??$$

$$f_c = (540 \rightarrow 1600) \text{ kHz}$$

SOL

a) for $f_{LO} > f_c$

$$f_{LO} = f_o = f_c + f_{IF} = (540 \rightarrow 1600) + 455$$

$$f_o = (540 + 455 \rightarrow 1600 + 455)$$

$$f_o = (995 \rightarrow 2055) \text{ kHz}$$



b) for $f_o < f_c$

$$f_o = f_c - f_{IF} = (540 - 455) \rightarrow (1600 - 455)$$

$$f_o = (85 \text{ kHz} \rightarrow 1145 \text{ kHz})$$

4

Sheet 4

1. A superheterodyne receiver must cover the range from 220 to 224 MHz. The first IF is 10.7 MHz; the second is 1.5 MHz. Find (a) the local oscillator tuning range, (b) the frequency of the second local oscillator, and (c) the first IF image frequency range. (Assume a local oscillator frequency higher than the input by the IF.)

(Sol)
i) $220 + 10.7 = 230.7 \text{ MHz}$

$$224 + 10.7 = 234.7 \text{ MHz}$$

Tuning range $\Rightarrow 230.7$ to 234.7 MHz

ii) $2^{\text{nd}} \text{ LO} = 1.5 \text{ MHz higher than the 1st IF}$
Therefore freq of $2^{\text{nd}} \text{ LO} = 10.7 + 1.5 = 12.2 \text{ MHz}$

iii) $230.7 + 10.7 = 241.4 \text{ MHz}$

$$234.7 + 10.7 = 245.4 \text{ MHz}$$

The first IF image frequency range. $\Rightarrow 241.4 - 245.4 \text{ MHz}$

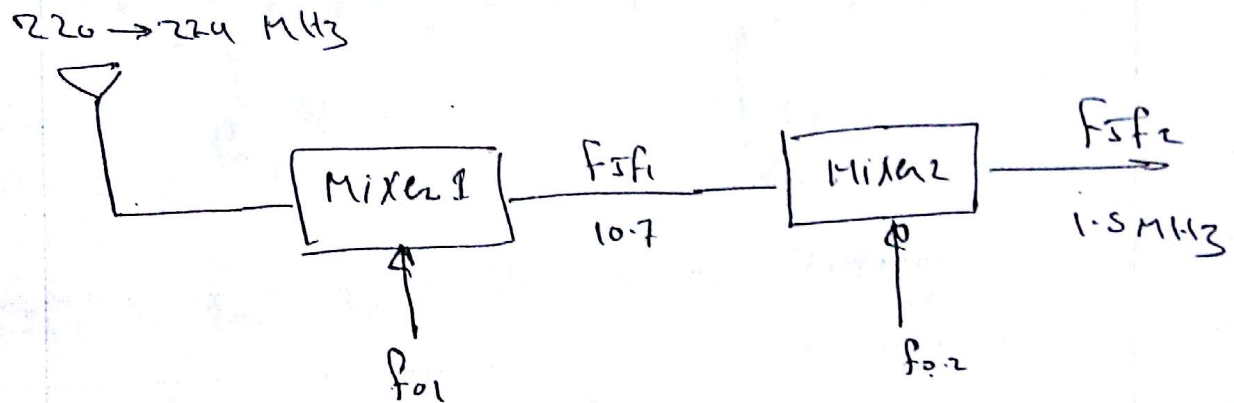
- =====
2. A dual-conversion superhet has an input frequency of 62 MHz and local oscillators of 71 and 8.6 MHz. What are the two IFs?

(Sol)

The products of the mixers can be the sum or the difference between the local oscillators and the signal. It is more likely though that the first IF is $71 - 62 = 9 \text{ MHz}$ and the second IF is $9 - 8.6 = 400 \text{ kHz}$.

① $f_c = (220 \rightarrow 224) \text{ MHz}$ $\leftarrow f_{sf1} = 10.7 \text{ MHz}$
 $f_{sf2} = 1.5 \text{ MHz}$

SOL



② $\therefore f_{o1} = f_c + f_{sf1} \Rightarrow f_{o1} = (220 \rightarrow 224) + 10.7$

$f_{o1} = 220 + 10.7 \rightarrow 224 + 10.7$

$f_{o1} = (230.7 \rightarrow 234.7) \text{ MHz} \Rightarrow \text{③}$

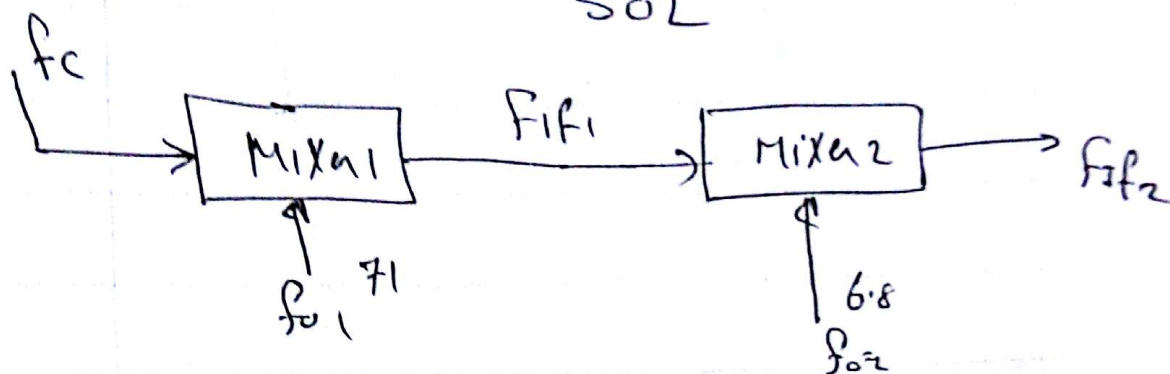
④ $f_{o2} = f_{sf1} + f_{sf2} = 10.7 + 1.5 = 12.2 \text{ MHz} \rightarrow \text{⑤}$

~~f_{sf1}~~ ⑥ $f_{imag} = f_c + 2f_{sf1} = (220 \rightarrow 224) + 2 \times 10.7$
 $= f_{o1} + 2f_{sf1}$

$f_{img} = (241.4 \rightarrow 245.4) \text{ MHz} \Rightarrow \text{⑦}$

$$f_c = 62 \text{ MHz} \quad f_{o1} = 71 \text{ MHz} \quad f_{o2} = 8.6 \text{ MHz}$$

SOL



$$f_{if1} = f_{o1} - f_c = 71 - 62 = 9 \text{ MHz}$$

$$f_{if2} = f_{o2} - f_{if1} = f_{if1} - f_{o2} \Rightarrow \text{المهم الزم}$$

بعض النظره اخرى

$$f_{if2} = |f_{o2} - f_{if1}| = |(8.6 - 9)| = 400 \text{ KHz}$$

ملاحظ

Dual Conversion باستخدام الـ (f_if1)

قد زادت قيمة ولباق وذا يكون خارج نظام الـ

Bus of the Rf tuned circuit.



Ex Let Bus of tuned circuit is 10 KHz at

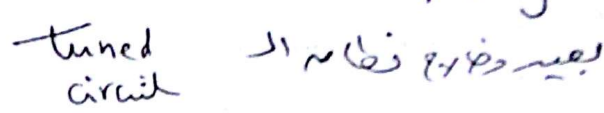
Center frequency of 1 MHz $\therefore f_{if1} = 800 \text{ KHz}$

$\therefore f_{if2} = 455 \text{ KHz}$ - Then $f_{img} = f_c + 2f_{if1} = 1 + 2 \times 800$

$$= 2.6 \text{ MHz}$$

2

~~ملاحظ~~



Let $f_c = 100 \text{ MHz}$ & $f_{sf} = 200 \text{ kHz}$

$$\therefore F_{img} = f_c + 2B_f = 100 \text{ MHz} + 2 \times 200 \text{ kHz} = 100.4 \text{ MHz}$$

